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Original Research

The use of ultrasound in the assessment of difficult laryngoscopy in children

Ultrasound vs cormack lehane classification

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Abstract
Aim: In this study, we aimed to investigate whether ultrasound anatomic measurements of the airway prior to anesthetic administration could be used as a predictive standard for difficult intubation in children undergoing surgery under general anesthesia.
Material and Methods: This observational study included 100 patients with an ASA I-III risk score between the ages of 0-6, whose operation was planned under general anesthesia. Age, height, body weight, Cormack-Lehane Classification and distance from skin to pre-epiglottic space (EPI), distance from skin to thyroid cartilage (TC), distance from skin to the anterior commissure (VCA) of vocal cord, distance from skin to posterior commissure (VCP) of the vocal cord and distance from skin to the hyoid bone (HYO) was recorded. These parameters were studied to examine the relationship between the classification of Cormack-Lehane.
Results: Cormack Lehane classification Grade III and above were determined in 9 (9%) patients. There was a statistically significant relationship between intubation difficulty and distance from skin to the thyroid cartilage.
Discussion: The ultrasound parameters we studied, with the possible exception of TC, which was not compared to any other anatomical, radiological or surface anatomy measurement, are virtually useless in predicting intubation difficulty in 0 – 3 years.

Keywords
Ultrasound, Cormack–Lehane Classification, Pediatric Difficult Intubation

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Introduction

In the pediatric population, 'intubation time' and 'airway security' are critical due to the anatomic and physiologic characteristics. In pediatrics, a smaller lung volume, and functional residual capacity in particular, considerably reduce apnea tolerance. Despite optimal preoxygenation of sufficient duration to prevent desaturation in children, no "safety period" can be established even for short-lasting apnea events [1,2]. Although measurement of anatomic structures and various scoring systems can be used, the Cormack–Lehane (CL) classification system has proven to be the best method for describing difficult intubation. CL classification has therefore become a standard for the investigational description of difficult laryngoscopy in anesthesia [3-5]. But although it is the standard for describing difficult intubation, it cannot be used in the preoperative evaluation as it is too invasive for a conscious patient [6].

Airway assessment by ultrasound is an important non-invasive, cost-effective, and instructive method. Although it has not yet been established as a standard method for assessing the airway of patients, it has great potential in the prediction of difficult airway [7]. However, there is a paucity of information focusing specifically on such methods in pediatric population where equipment, technique, and challenges are different [8].

In the present study, the aim was to investigate whether ultrasound anatomic measurement of the airway prior to anesthetic administration could be used as a predictive standard for difficult intubation in children undergoing surgery under general anesthesia.

Material and Methods

The study was conducted after obtaining written informed consent from the parents after the approval of the local ethics committee (2019/463) and in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki revised in the year 2000.

A total of 100 patients who were aged 0–6 years, included in ASA (American Society of Anesthesiologists) classification groups I–III, and scheduled for endotracheal intubation under general anesthesia prior to elective surgery were included in the study. Patients without parental consent, with significant airway malformations, with head and neck deformities were excluded from the study. All tests and endotracheal intubation attempts in the study were performed by the same surgeon with four years of experience.

Demographic characteristics recorded in the preoperative evaluation were age, sex, body weight, weight percentile, height, and body mass index (BMI). For all patients whose difficult intubation was assessed with CL classification and ultrasound, the distances between the pre-epiglottic space and the skin (EPI), between the thyroid cartilage and the skin (TC), between the anterior commissure of the vocal cord and the skin (VCA), between the posterior commissure of the vocal cord and the skin (VCP), and between the hyoid bone and skin (HYO) were measured in centimeters. Ultrasound examinations were performed using a GE LOGIQ e (GE Healthcare, USA) ultrasound scanner.

Midazolam at a dose of 0.02 mg/kg was administered intravenously to all patients as premedication before surgery. After the patient was taken to the operating room, standard monitoring (ECG, pulse oximetry, non-invasive arterial blood pressure) was performed. During induction, bolus doses of 0.5–1 μg/kg of fentanyl and 1-2 mg/kg of propofol were administered intravenously. After establishing that the patient was able to be ventilated with an appropriate mask, rocuronium was administered intravenously at 0.6 mg/kg in order to induce muscle relaxation. Laryngoscopy was initiated 2–3 minutes after the administration of rocuronium.

Under ventilation with a mask, the neck was brought into extension for measurement. A hockey stick probe (8–16 MHz) placed transversely in the submandibular region of the patient was moved in the transverse plane from cranial to caudal without changing its position. Distances between the hyoid bone and the skin (HYO), between the pre-epiglottic space and the skin (EPI), between the thyroid cartilage and the skin (TC), between the anterior commissure of the vocal cord and the skin (VCA), and between the posterior commissure of the vocal cord and the skin (VCP) were measured in centimeters and recorded. Direct laryngoscopy was performed with Macintosh blades 0, 1, or 2. The condition of the vocal cords was assessed through their laryngoscopic appearance using CL classification. Patients were intubated and any complications during laryngoscopy were recorded.

In accordance with the CL classification system, if the glottis was completely visible, the patient was evaluated as grade I; if it was partially visible, they were evaluated as grade II; if only the epiglottis was visible, they were evaluated as grade III; and if even the epiglottis was not visible, they were evaluated as grade IV. Intubation was considered difficult if the CL test was grade III and IV despite appropriate head and neck position and the use of a laryngoscope blade.

Statistical analysis

The IBM SPSS Statistics 22 (IBM SPSS, Turkey) program was used for statistical analysis. The G Power program was used for power analysis. The conformity of numerical variables with the normal distribution was examined using the Shapiro-Wilk test. In the analysis of the study data, in addition to descriptive statistical methods (mean, standard deviation, median, frequency), the Student's t-test was used to compare normally distributed parameters between two groups, while the Mann-Whitney U test was used to compare non-normally distributed parameters between two groups. When comparing three independent groups, an ANOVA test was used for normally distributed numeric variables, while the Kruskal-Wallis and Dunn's tests were used for non-normally distributed variables. ROC analysis was performed to determine the threshold for significant levels. The MedCalc package program version 19.2.1 was used for ROC analysis. A p-value of less than 0.05 was accepted as significant.

Ethical Approval

Ethics Committee approval for the study was obtained.

Results

The study was conducted on 100 patients aged 0 to 6 years, including 68 (68%) boys and 32 (32%) girls. Of the patients with difficult intubation, seven (77.8%) were male and two

(22.2%) were female. Sixty patients were classified as being ASA I (60%), 30 as ASA II (30%), and 10 as ASA III (10%). The C–L classification was grade I in 34 cases, grade II in 57 cases, and grade III in nine cases. There were no grade IV cases. As grades III and IV were considered difficult intubation, difficult intubation was noted in nine patients (9%), while there was no unsuccessful intubation.

The mean age of the patients was 2.1±1.44 years, mean body weight was 11.72±4.56 kg, mean height was 86.62±17.92 cm, and weight percentile was 41.96±28.95. Two of the cases were in the 3% percentile (1.9%), 12 were in the 5% percentile (11.5%), 12 were in the 10% percentile (11.5%), four were in the 15% percentile (3.8%), 16 were in the 25% percentile (15.4%), 26 of them were in the 50% percentile (25%), 14 of them were in the 75% percentile (13.5%), 12 were in the 85% percentile (11.5%), and two were in the 90% percentile (1.9%).

In the study parameters of the cases, VCA was determined as 0.49±0.06 cm, VCP as 1.41±0.17 cm, HYO as 0.54±0.11 cm, TC as 0.42±0.09 cm, and EPI as 1.9±0.22 cm, as the mean values of measurement. When we compared them, evaluated these parameters against one another in ratios, the mean value of VCA/VCP was 0.35±0.05, EPI/VCA was 3.93±0.46, and EPI/VCP was 1.36±0.46 (Table 1).

The mean age of the patients with difficult intubation was 1.88±1.22 years, the mean body weight was 10.83±4.16 kg, the mean height was 83.22±16.99 cm, and the weight percentile was 28.89±17.09.

In accordance with their CL classification, the cases were divided into two groups: difficult and simple intubation. There was no statistically significant relationship between intubation difficulty and VCA, VCP, HYO, EPI, EPI/VCP ratio, and EPI/VCA ratio ($p>0.05$). There was a statistically significant relationship between intubation difficulty and TC ($p<0.05$). There was a statistically significant relationship between intubation difficulty and VCA/VCP ratio ($p<0.05$) (Table 2).

The statistical sensitivity of TC was 77.78%, its specificity was 72.53%, and its cut-off value was 0.38 cm. The statistical sensitivity of the VCA/VCP ratio was 66.67%, its specificity was 82.42%, and its cut-off value was 0.31 cm (Figure 1).

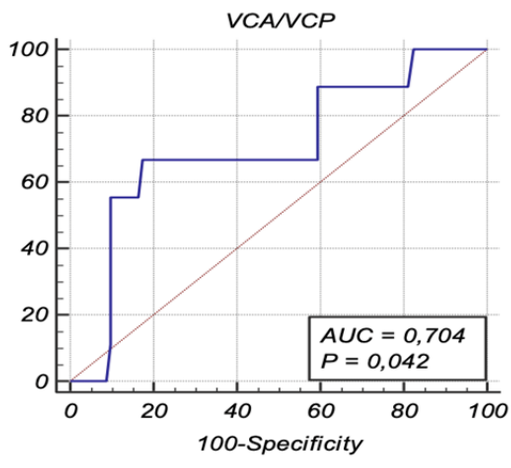

Figure 1. ROC curve of VCA/VCP ratio.

Table 1. Airway anatomical measurements of the patients.

	Minimum	Maximum	Mean
VCA (cm)	0.33	0.63	0.49±0.06
VCP (cm)	0.89	1.75	1.41±0.17
HYO (cm)	0.35	0.79	0.54±0.11
TC (cm)	0.27	0.62	0.42±0.09
EPI (cm)	1.45	2.44	1.90±0.22
VCA/VCP	0.26	0.58	0.35±0.05
EPI/VCP	1.16	2.34	1.36±0.18
EPI/VCA	3.4	4.95	3.93±0.46

SD: Standard Deviation, EPI: distance between pre-epiglottic space and the skin, TC: distance between the thyroid cartilage and the skin, VCA: distance between the anterior commissure of the vocal cord and the skin, VCP: distance between the posterior commissure of the vocal cord and the skin, HYO: distance between the hyoid bone and the skin.

Table 2. Comparisons according to easy/difficult intubation.

	Easy (n=91) Mean±SD	Difficult (n=9) Mean±SD	p
VCA	0.49±0.06	0.48±0.02	0.522
VCP	1.40±0.17	1.51±0.13	0.06
HYO	0.55±0.11	0.52±0.08	0.763
TC	0.42±0.10	0.35±0.06	0.027*
EPI	1.89±0.22	1.95±0.12	0.281
VCA/VCP	0.35±0.05	0.32±0.04	0.044*
EPI/VCP	1.36±0.19	1.29±0.10	0.189
EPI/VCA	3.91±0.46	4.6±0.44	0.352

SD: Standard Deviation, EPI: distance between the pre-epiglottic space and the skin, TC: distance between the thyroid cartilage and the skin, VCA: distance between the anterior commissure of the vocal cord and the skin, VCP: distance between the posterior commissure of the vocal cord and the skin, HYO: distance between the hyoid bone and the skin * $p<0.05$ significant

Discussion

The aim of the present study was to investigate whether ultrasound anatomic measurement of the airway prior to anesthetic administration could be used as a predictive standard for difficult intubation in children undergoing surgery under general anesthesia.

Skilled airway management is the cornerstone of high-quality anesthesia management. Airway complications remain a common cause of anesthesia-related complications in children because of their unique anatomy and physiology [9]. In a retrospective study of 11,219 pediatric patients undergoing general anesthesia with endotracheal intubation, the rate of difficult direct laryngoscopy (CL grades III and IV) was 1.35%. The rate of direct difficult laryngoscopy was highest in children younger than 1 year old (0.7% in children older than 1 year vs. 4.7% in children younger than 1 year). Other predictors of difficult intubation were being classified as ASA III or IV, having a higher Mallampati score (if available), a lower body mass index, and a history of oromaxillofacial or cardiac surgery [10]. Valois-Gomez et al. reported that the incidence of intubation difficulty was 1.2% in a sample of 484 children aged 0 to 8 years [11]. In a prospective multicentre study by Fiadjoe et al., difficult tracheal intubation occurred in 2–5 per 1000 pediatric anesthesia cases [12].

Many different airway measurements have been used to predict difficult laryngoscopy in children. In a study on the

airway of children younger than 5 years undergoing cardiac catheterization, it was concluded that body mass index, lower lip-to-chin distance (LCD), and thyromental distance (TMD) could be used to predict difficult laryngoscopic view. In the same study, the incidence of difficulty in viewing the larynx was 4% [13]. However, our study found a higher rate than these studies, with an incidence of 9% for difficulty in viewing the larynx.

It is critical to assess and recognize the potential for difficult airway prior to any procedure so that appropriate equipment and resources are available. For this reason, it has been emphasized that the relationship between various sonographic parameters and difficult airway should be investigated using point-of-care ultrasound (POCUS) for airway evaluation [14]. Ultrasound has many advantages in upper airway imaging; it is safe, fast, portable, and accessible. It provides real-time static and dynamic images of various clinical indications of airway management [15].

In a study on 130 adult patients, Parameswari et al [16]. found that an ultrasonographically-measured distance between the epiglottis and the skin, based on CL classification, was the most sensitive (75% sensitivity) and the most specific (63.6% specificity) parameter in predicting difficult laryngoscopy. In a study on 301 patients, Falcetta et al [17] measured anterior cervical soft tissue thickness with ultrasound at two levels (thyrohyoid membrane [epiglottic area] and vocal cords [entry of the larynx]) on adult patients and found a high correlation between pre-epiglottic tissue thickness at the level of the thyrohyoid membrane and CL classification in predicting limited/difficult intubation. The fact that we have not come across any significant findings in the epiglottis region can be explained by the fact that our study was performed on pediatric patients.

In a pilot study conducted with 51 adult patients, Adhikari et al. [18] demonstrated that sonographic measurements of anterior neck soft tissue thickness at the level of the hyoid bone and thyrohyoid membrane can be used to discriminate between difficult and easy laryngoscopy, by comparing the anterior neck soft tissue thickness measured at the level of the hyoid bone and thyrohyoid membrane against CL classification. The present study demonstrated a statistically significant correlation between the difficulty of intubation and the distance between the thyroid cartilage and the skin.

In their study on 72 patients, Gupta et al. [19] found that the PES/EVC (pre-epiglottic space/distance between the epiglottis and the vocal cord) value was positively correlated with CL classification. In a study conducted with 100 patients, Reddy et al [3] showed that when measurements are taken using ultrasonography and based on CL classification, the PES/EVC value has a low-to-moderate predictive value in predicting difficult intubation. The sensitivity of the PES/EVC value was 1.2%, its specificity was 86.7%, its positive predictive value was 33.3, and its negative predictive value was 13.4%. There was a statistically significant relationship between intubation difficulty and the VCA/VCP ratio in this present study. However, we believe that there is room for more studies in this field as the results and anthropometric measurements of ultrasound studies are influenced by various parameters such as race and geography.

Conclusion

In this present study, TC and the VCA/VCP ratio were found to have a statistically significant relationship with CL classification. However, due to the multiple anatomic factors involved in difficult intubation and the lack of an ideal prediction test, an unexpectedly difficult airway should always be considered. Radiographic examination of the anatomy of the region, a method which has recently gained importance, can help predict difficult intubation during physical examination. The ultrasound parameters we studied, with the possible exception of TC, which was not compared to any other anatomical, radiological or surface anatomy measurement, are virtually useless in predicting intubation difficulty in 0 – 3 years.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest

None of the authors received any type of financial support that could be considered potential conflict of interest regarding the manuscript or its submission.

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